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THE DEMOGRAPHIC AND MORPHOLOGICAL FEATURES OF ROTATOR CUFF DISEASE

A COMPARISON OF ASYMPTOMATIC AND SYMPTOMATIC SHOULDERS

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Background: Very little comparative information is available regarding the demographic and morphological characteristics of asymptomatic and symptomatic rotator cuff tears. This information is important to provide insight into the natural history of rotator cuff disease and to identify which factors may be important in the development of pain. The purpose of the present study was to compare the morphological characteristics and prevalences of asymptomatic and symptomatic rotator cuff disease in patients who presented with unilateral shoulder pain.

Methods: Five hundred and eighty-eight consecutive patients in whom a standardized ultrasonographic study had been performed by an experienced radiologist for the assessment of unilateral shoulder pain were evaluated with regard to the presence and size of rotator cuff tears in each shoulder. The demographic factors that were analyzed included age, gender, side, and cuff thickness. All of these factors were evaluated with regard to their correlation with the presence of pain.

Results: Of the 588 consecutive patients who met the inclusion criteria, 212 had an intact rotator cuff bilaterally, 199 had a unilateral rotator cuff tear (either partial or full thickness), and 177 had a bilateral tear (either partial or full thickness). The presence of rotator cuff disease was highly correlated with age. The average age was 48.7 years for patients with no rotator cuff tear, 58.7 years for those with a unilateral tear, and 67.8 years for those with a bilateral tear. Logistic regression analysis indicated a 50% likelihood of a bilateral tear after the age of sixty-six years ($p < 0.01$). In patients with a bilateral rotator cuff tear in whom one tear was symptomatic and the other tear was asymptomatic, the symptomatic tear was significantly larger ($p < 0.01$). The average size of a symptomatic tear was 30% greater than that of an asymptomatic tear. Overall, patients who presented with a full-thickness symptomatic tear had a 35.5% prevalence of a full-thickness tear on the contralateral side.

Conclusions: There is a high correlation between the onset of rotator cuff tears (either partial or full thickness) and increasing age. Bilateral rotator cuff disease, either symptomatic or asymptomatic, is common in patients who present with unilateral symptomatic disease. As the size of a tear appears to be an important factor in the development of symptoms, we recommend surveillance at yearly intervals for patients with known rotator cuff tears that are treated nonoperatively.

Rotator cuff disease ranks among the most prevalent of musculoskeletal disorders, with as many as 17 million individuals in the United States at risk for disability[1,2]. Although it appears that a vast majority of individuals with rotator cuff tears are asymptomatic, they represent a substantial population at risk for the development of pain[1-4]. Given their clinical importance, surprisingly little comparative information is available regarding asymptomatic and symptomatic rotator cuff tears[5-7]. Such information may lend insight into the natural history of rotator cuff disease and into which factors may be important for the development of symptoms[6].

The use of shoulder ultrasound has been a primary imaging modality at our institution since 1989[8-10]. The technique has been validated to be highly accurate for both the detection

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and the characterization of rotator cuff tears[11]. Additionally, according to protocol, bilateral shoulder examinations have been performed routinely. This presented a unique opportunity to compare the findings of a large number of bilateral shoulder examinations in patients who presented with unilateral pain. The purpose of the present study was to compare the morphological and demographic findings associated with asymptomatic and symptomatic rotator cuff disease in patients who presented with unilateral shoulder pain.

Materials and Methods

Clinical

The records for 588 consecutive patients who had had an ultrasonographic evaluation of both shoulders between June 1996 and July 2001 for the evaluation of unilateral shoulder pain were retrospectively studied. All studies had been performed in real time with use of an ATL HDI 5,000 Scanner (Advanced Technologies Laboratory, Bothell, Washington). According to protocol, all patients had undergone standardized bilateral ultrasonography of the shoulder. A full-thickness rotator cuff tear was recorded when the rotator cuff could not be visualized because of complete avulsion and retraction under the acromion or when a focal defect in the rotator cuff was created by a variable degree of retraction of the torn tendon edges. If no tear was visualized, the deltoid muscle was compressed against the cuff with a transducer in an attempt to separate the torn edges at the side of a nonretracted tear. A partial-thickness tear was recorded when there was minimal flattening of the bursal side of the rotator cuff or when a distinct hypoechoic or mixed hypoechoic defect was visualized in both the longitudinal and transverse planes.

The subjects who were involved in the study included patients who (1) had undergone an ultrasound examination of both shoulders for the investigation of unilateral shoulder pain and (2) had complete data for both shoulders regarding the presence, absence, size, and location of any rotator cuff abnormality. The exclusion criteria were (1) the presence of bilateral symptoms, (2) a previous surgical procedure on either shoulder, (3) inflammatory arthropathy, and (4) preceding trauma.

The review of medical records was approved by our local institutional review board. Of the 588 consecutive patients who met the inclusion criteria, 212 had an intact rotator cuff bilaterally, 199 had a unilateral rotator cuff tear (either partial or full thickness), and 177 had a bilateral tear (either partial or full thickness).

In addition to the 588 patients who were included in the study, there were fifty-two patients who were excluded because the records were incomplete. The majority of these records did not state whether the contralateral shoulder was painful or nonpainful. Sixty-six patients were eliminated because of the presence of bilateral shoulder pain.

Ultrasonography

The high-resolution ultrasound examinations were performed by two experienced radiologists (S.A.T. and W.D.M.) in a standardized fashion, with partial and full-thickness tears defined as previously described[11]. A high-resolution linear-array transducer with the center of frequency ranging from 7 to 10 MHz was used[11]. The images included longitudinal and transverse images of the rotator cuff.

As a matter of protocol, patients were asked if one or both shoulders were considered to be painful, and this information was recorded. Additionally, patients were asked whether or not they had had a previous operation. The size of a rotator cuff tear was recorded at the level of the anatomic neck in the transverse dimension. Tears that measured ≤15 mm were considered to involve only the supraspinatus or one tendon. Tears that measured >15 mm but ≤30 mm were considered to involve both the supraspinatus and the infraspinatus tendon. Tears that measured >30 mm in the transverse dimension were considered to include the supraspinatus, the infraspinatus, and part of the teres minor and thus were considered massive.

Data Analysis

Data on the age of the patient; the thickness of the rotator cuff (when intact); the presence or absence of an intact rotator cuff, a partial-thickness tear, or a full-thickness tear; the size of the tear; and pain were all tested for statistical associations. Specifically, we examined the thickness of the rotator cuff as a function of gender, age, and pain. Additionally, we tested the size of the tear as a function of age and symptoms.

Statistical Analysis

For the data on intact rotator cuffs, associations between cuff thickness, gender, age, and pain were tested with the T test, the paired T test, Fisher's exact test, regression analysis, and multivariate analysis of variance. The quality of variances was tested with the O'Brien, Brown-Forsythe, Levene, and Vartlett tests. Testing was performed with use of JMP statistical software (SAS Institute, Cary, North Carolina).

For the data on partial or full-thickness rotator cuff tears, the associations among the presence of cuff tears, the size of cuff tears, pain, and age were tested for significance with the T test, the paired T test-Wilcoxon signed-rank test, regression analysis, logistic regression analysis, and multivariate analysis of variance. The quality of the variances was tested with the O'Brien, Brown-Forsythe, Levene, and Vartlett tests. Tests for the normality of distributions were performed with the Shapiro-Wilk W test. Testing was performed again with use of JMP statistical software (SAS Institute).

Results

Clinical

The overall average age (and standard deviation) of the 376 patients with a rotator cuff tear was 62.8 ± 11.3 years. In this group, significantly more patients (244 [65%] of 376) had pain on the right side ($p < 0.01$).

Unilateral Tears

One hundred and ninety-nine patients presented with a uni-

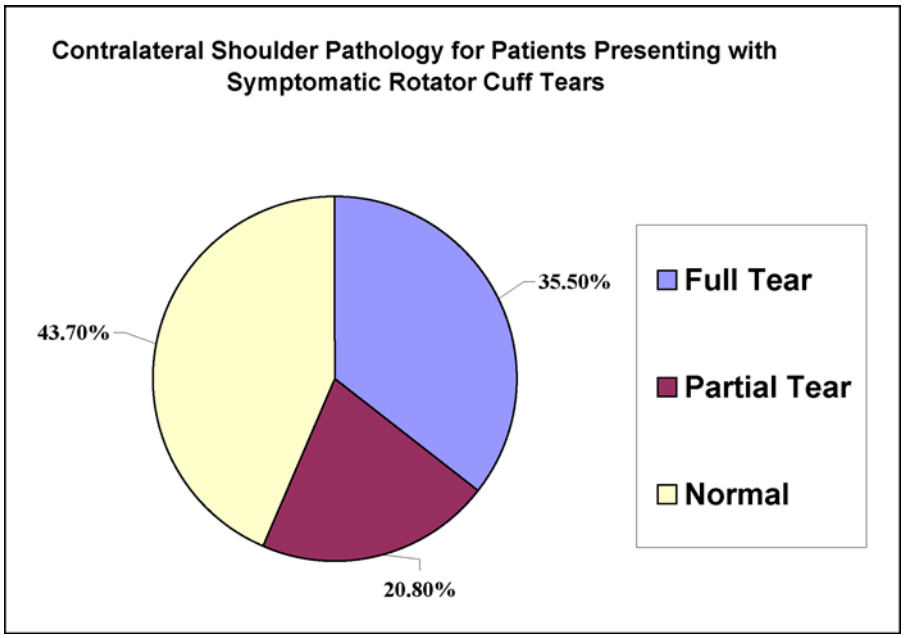

Fig. 1

Illustration depicting the prevalence of contralateral rotator cuff disease among patients who presented with a symptomatic unilateral full-thickness rotator cuff tear. Such patients had a 35.5% chance of having a full-thickness tear on the contralateral, nonpainful side. Only 43.7% of such patients had normal findings on the contralateral side.

lateral tear. Ninety-seven of these 199 patients had a partial-thickness tear, and 102 had a full-thickness tear. Of the ninety-seven partial-thickness tears, ninety-three were painful and four were not painful. Of the 102 full-thickness tears, 101 were painful and one was not painful.

Bilateral Tears

One hundred and seventy-seven patients with unilateral pain presented with a bilateral tear. Eighty-two of these 177 patients had a bilateral full-thickness rotator cuff tear. The remaining ninety-five patients in this group had at least one partial-thickness tear. Among these ninety-five patients, forty-one had a bilateral partial-thickness tear, six had a partial-thickness tear in the painful shoulder and a full-thickness tear in the nonpainful shoulder, and forty-eight had a full-thickness tear in the painful shoulder and a partial-thickness tear in the nonpainful shoulder.

Prevalence of Rotator Cuff Tears

The prevalence of rotator cuff disease increased with age. There was an approximately ten-year difference between the three subgroups of patients: the average age was 48.7 years for patients with no rotator cuff tear, 58.7 years for those with a unilateral tear, and 67.8 years for those with a bilateral tear. Logistic regression analysis showed a 50% likelihood of a bilateral tear after the age of sixty-six years ($p < 0.01$).

If a patient presented with a full-thickness tear on the painful side, he or she had a 35.5% (sixty-five in 183) chance of having a full-thickness tear on the contralateral (asymptomatic) side, a 20.8% (thirty-eight in 183) chance of having a partial-thickness tear on the contralateral side, and only a 43.7% (eighty in 183) chance of having normal findings on the contralateral side (Fig. 1).

If a patient presented with a partial-thickness tear on the painful side, he or she had a 4.3% (six in 140) chance of having a full-thickness tear on the contralateral (asymptomatic) side, a 29.3% (forty-one in 140) chance of having a partial-thickness tear on the contralateral side, and a 66.4% (93 in 140) chance of having normal findings on the contralateral side.

In contrast, if a patient presented with normal findings on the painful side, there was very little chance of rotator cuff disease on the contralateral (asymptomatic) side. Specifically, such a patient had only a 0.5% (one in 217) chance of having a full-thickness tear on the contralateral side, a 1.8% (four in 217) chance of having a partial-thickness tear on the contralateral side, and a 97.7% (212 in 217) chance of having normal findings on the contralateral side (Fig. 2).

Correlation with Tear Size

The median tear width for asymptomatic shoulders was 15.0 mm (indicating involvement of only the supraspinatus tendon). The corresponding mean values were 17.3 ± 10.0 mm for nonpainful shoulders and 18.8 ± 10.6 mm for painful shoulders (indicating involvement of both the supraspinatus and infraspinatus tendons). Age was not significantly related to the size of the tear in shoulders with or without pain ($r^2 < 0.01$, $p = 0.37$). Tear width measurements were available

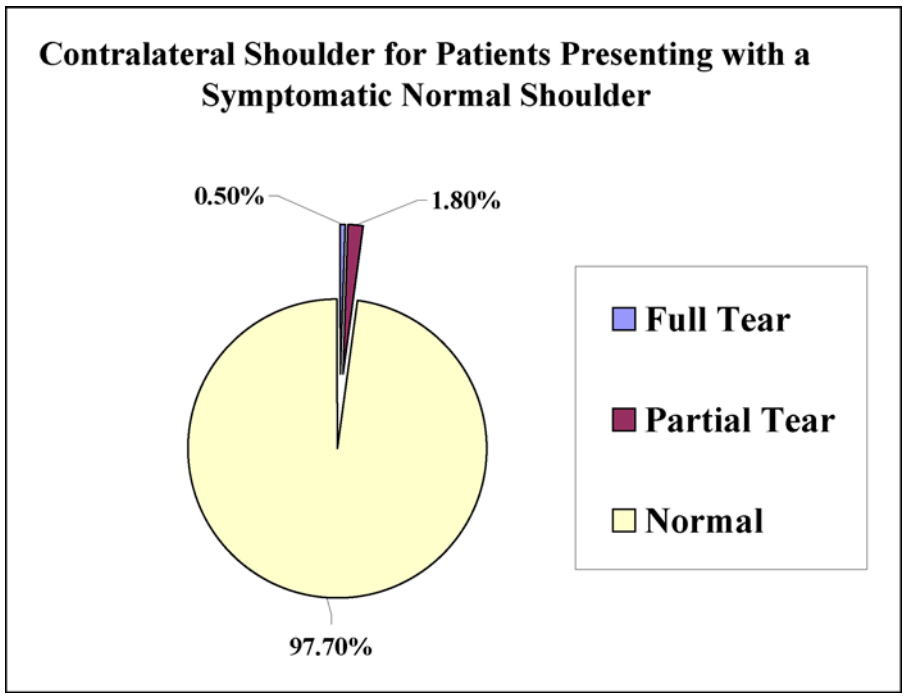

Fig. 2

Illustration depicting the prevalence of contralateral rotator cuff disease among patients who presented with a symptomatic shoulder without a rotator cuff tear. Such patients had a 1.8% chance of having a partial-thickness tear on the contralateral, nonpainful side and only a 0.5% chance of having a full-thickness tear on the contralateral, nonpainful side.

for eighty-two patients who had a bilateral tear. For shoulders with no pain, the mean and median tear widths were 17.4 ± 10.0 mm and 15.0 mm, respectively. For shoulders with pain, the mean and median tear widths were 22.7 ± 10.0 mm and 23 mm, respectively (indicating involvement of both the supraspinatus and infraspinatus tendons). The mean difference in size between painful and nonpainful shoulders in patients with bilateral tears was 5.4 mm (95% confidence interval, 7.4 to 3.3 mm) ($p < 0.01$). Age did not significantly affect this relationship.

Shoulders with an Intact Rotator Cuff

Two hundred and twelve patients (including 112 female patients and 100 male patients) had an intact rotator cuff. The average age of the female patients was significantly greater than that of the male patients (50.6 compared with 47.2 years; $p = 0.03$). There was not a difference between male and female patients with regard to the distribution of which side was painful. The right side was painful in fifty-nine (53%) of the 112 female patients and in fifty-four (54%) of the 100 male patients ($p = 0.89$). In male patients, the mean rotator cuff thickness was 4.7 ± 0.8 mm in painful shoulders and 4.6 ± 0.9 mm in nonpainful shoulders. This small difference was not significant ($p = 0.34$). Multivariate analysis of variance did not identify significant relationships between gender, age, and cuff thickness between shoulders with and without pain.

Discussion

To date, the epidemiology of symptomatic and asymptomatic rotator cuff tears has been poorly characterized. Most previous studies on the prevalence of rotator cuff disease were performed on cadavers, and very little information was available regarding the presence or absence of pain or other demographic factors such as age[12-19]. Given these limitations, previous studies of cadavers have demonstrated a potentially large prevalence of rotator cuff tears, ranging from 9.4% (eighteen of 192) in the study by Keyes[18] to 39% (thirty-nine of 100) in the study by DePalma et al.[13], with an increasing frequency in older individuals[12-19]. Two prospective studies, one performed with magnetic resonance imaging and the other performed with ultrasonography, investigated the prevalence of rotator cuff tears in individuals without pain and with apparently normal function[1,2]. Sher et al. reported that thirteen (28%) of forty-six patients who were more than sixty years old had a full-thickness tear[2]. Milgrom et al., in a study conducted with ultrasonography, reported that fifteen (65%) of twenty-three patients who were more than seventy years old had a rotator cuff tear[1]. Correlations with gender, cuff thickness, and cuff tear size were unavailable in those studies. Most importantly, no direct comparison between painful and nonpainful shoulders was performed.

Despite the relative paucity of demographic information in previous studies, it is apparent that a substantial proportion of individuals over the age of sixty years have rotator cuff tears.

The clinical importance of rotator cuff tears in these apparently asymptomatic individuals is unknown[6,7]. However, this issue is quite important because individuals with asymptomatic tears represent a very large at-risk population for whom secondary prevention intervention (early detection and treatment of disease before it becomes symptomatic)[6,7] may be helpful.

A previous study from our institution involving a small cohort of patients suggested that a large percentage of individuals with previously asymptomatic tears are at risk for the development of new-onset pain when seen for the evaluation of contralateral shoulder pain[6]. In that study, twenty-three of forty-five previously asymptomatic individuals became symptomatic over a mean of 2.8 years after the onset of pain in the contralateral shoulder. The development of symptoms was associated with a significant ($p < 0.05$) increase in pain and a decrease in the ability to perform activities of daily living. In the present study, the finding of a strong (50%) likelihood of a bilateral tear after the age of sixty-six years is consistent with an intrinsic etiology for rotator cuff tears associated with natural aging.

The high rate of bilateral disease can be important during the workup of an individual who presents with unilateral shoulder pain. Our data showed that 35.5% of the patients who presented with a full-thickness tear on the painful side had a full-thickness tear on the nonpainful, contralateral side. This information is particularly important in the context of our previous study, which suggested that a large percentage of these tears may be associated with the development of pain in the future. In contrast, if a patient had either a partial-thickness tear or a normal rotator cuff on the painful side, the rate of a full-thickness tear on the contralateral, asymptomatic side was low (4.3% and 0.5%, respectively).

In our previous longitudinal study of asymptomatic tears, nine of twenty-three patients had an increase in tear size over time[6]. Although significance could not be detected with the small numbers available, there appeared to be a trend toward a correlation between tear size progression and the development of new symptoms. The results of the present study appear to substantiate this finding. In a direct comparison of the eighty-two patients with a bilateral tear, with a painful tear on one side and a nonpainful tear on the other side, there was a significant difference in tear width associated with symptoms. On the average, painful shoulders had a 30% larger rotator cuff tear than nonpainful shoulders did.

The present study had several limitations that are important to recognize. This was a retrospective study, and therefore a careful prospective analysis of symptoms was not performed. Although the radiologists asked the patients if they considered the shoulders to be painful or nonpainful, the answers were highly subjective and were not carefully quantitated with use of visual analog pain scales. In addition, the presence or absence of pain was not further correlated with functional abilities, which is an important consideration in determining the association of symptoms. The prevalences that we found also were specific to a population of patients with a contralateral symptomatic shoulder and cannot be generalized to patients with rotator cuff disease in whom both shoulders are nonpainful. However, the results were very relevant to a substantial at-risk population, namely, patients who present with pain and have contralateral nonpainful disease. The strengths of the present study include the large number of patients and the accuracy of the surveillance tool that was used (ultrasonography). However, although ultrasonography is quite accurate for the detection and characterization of full-thickness tears, it should be noted that it is less so for partial-thickness tears. This lack of accuracy for determining exact size and location precluded further specific analysis of these variables.

Our data demonstrated that specific age-groups are at a higher risk for the presence of full-thickness rotator cuff disease. We believe that patients who undergo nonoperative treatment of symptomatic or asymptomatic full-thickness rotator cuff tears should be monitored for tear size progression over time. In our practice, we generally do this by asking a patient to return in six months for repeat ultrasonography. If that study does not show tear size progression, then repeat ultrasound studies are suggested to the patient on a yearly basis. The patient is also warned that any new increase in pain should prompt a return for a follow-up evaluation, including ultrasonography, to verify that the tear has not gotten larger. Follow-up for such patients is important because the development of new symptoms may indicate enlargement of the tear. ■

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